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Route To: (2400)

Subject: Evaluation of Salt Toxicity of Ponderosa Pine Along State Highway 260, Black Mesa RD, Apache-Sitgreaves NF

To: Kathleen Klein, District Ranger, Black Mesa RD

At your request, I recently surveyed an area of ponderosa needle discoloration, dieback, and mortality along Highway 260, from the visitor center to the town of Heber, and collected needle samples for salt analysis. Of the roughly 20 miles surveyed, about 14 miles contained groups of trees on either-or-both sides of the roadway exhibiting signs of salt damage. Symptoms included tip burn (yellow to brown needle tips with green bases on one-year needles), differential discoloration on the side of the crown closest to the roadway, entire crown of trees with tip burn, branch dieback, topkill, and mortality. The largest area of mortality was approximately one mile east of the visitor center. This letter summarizes the salt analysis and the effects of salt on ponderosa pine.

Needle Sampling and Analysis

Eight pairs of needle samples were collected at approximately 2 mile intervals from symptomatic and asymptomatic (non-symptomatic) trees. Needles from a tree with clear and pronounced symptoms of salt damage (drooping needles, tip burn, foliage discoloration) were collected to represent a symptomatic tree and then needles from the nearest asymptomatic tree were collected. Each sample was placed in a Ziploc plastic bag, labeled, and stored at 40 F. The distance from each tree trunk to the edge of the road was measured and recorded. Under the direction of Dana Erickson, Analytical Chemist for the Rocky Mountain Research Station, Flagstaff, the samples were ground, dried, and analyzed for content of sodium, magnesium, calcium, and chloride using ion chromatography for water-soluble ions. Data were then subjected to paired t-tests.

Foliage samples collected from symptomatic trees yielded significantly higher concentration of sodium and chloride (P values <0.001) than did samples from asymptomatic trees (Table 1). Symptomatic trees averaged 0.5% sodium and 0.9% chloride concentrations, over twelve and three times greater, respectively, than the average level of sodium (0.04%) and chloride (0.3%) in asymptomatic samples. Levels of magnesium and calcium were not significantly different between symptomatic and asymptomatic samples. Discolored trees were significantly closer to the road (P values <0.001) than green trees, with affected trees averaging 24 feet compared to unaffected trees which averaged 54 feet.

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Table 1. Sodium (Na), magnesium (Mg), calcium (Ca), and chloride (Cl) levels (% dry weight) from symptomatic (S) and asymptomatic (A) ponderosa pine needles collected along Highway 260 in Arizona.

Sample	Na (mg/g)	Mg (mg/g)	Ca (mg/g)	Cl (mg/g)	Distance from road (ft)	Slope
A1	0.074	0.108	0.056	0.271	45	Flat
A2	0.032	0.074	0.042	0.200	28	Uphill
A3	0.021	0.075	0.038	0.257	32	Flat
A4	0.104	0.114	0.073	0.390	80	Downhill
A5	0.024	0.071	0.053	0.245	63	Downhill
A6	0.016	0.061	0.029	0.326	35	Downhill
A7	0.046	0.130	0.036	0.439	80	Downhill
A8	0.034	0.204	0.042	0.263	69	Downhill
S1	0.365	0.123	0.061	1.019	24	Flat
S2	0.646	0.079	0.035	0.887	10	Uphill
S3	0.487	0.023	0.002	0.431	25	Flat
S4	0.403	0.078	0.020	0.585	30	Downhill
S5	0.604	0.163	0.089	1.570	15	Downhill
S6	0.702	0.065	0.040	0.972	14	Downhill
S7	0.455	0.288	0.035	0.762	35	Downhill
S8	0.353	0.301	0.124	1.023	37	Downhill

Discussion

It is clear from the chemical and statistical analysis that sodium and chloride levels are statistically higher in damaged ponderosa pine along Highway 260. Since the Arizona Department of Transportation (ADOT) uses de-icing and anti-icing salts along this highway (http://www.azdot.gov/Highways/districts/flagstaff/ADOTRole.asp), the evidence supports the interpretation that damage is from these salts. Both the 0.5% average sodium concentration and 0.9% average chloride concentration found in needles from affected plants are higher than the 0.34% and 0.5%, respectively, known to produce symptoms of salt toxicity in ponderosa pine[1].

We had expected to find higher levels of magnesium ion in symptomatic needles because ADOT states its use of magnesium chloride for anti-icing and de-icing roads. Although magnesium chloride has been reported by some researchers to be less toxic to plants than sodium chloride, in excessive concentrations it can also cause needle discoloration, dieback and death. In 2000, we found elevated levels of both magnesium and chloride ions in symptomatic ponderosa pine along a roadway outside of Pinetop sprayed for dust abatement.

The effects of salt on trees adjacent to roads have been documented since the 1940's[2], when it was first observed that salts applied as a dust palliative (CaCl) or for deicing (NaCl and CaCl) [3] caused leaf scorch, twig dieback, and death. Since that time, studies conducted across the globe have established salt damage to roadside trees. Damage can be caused either by salt spray thrown on the aerial parts of trees from fast moving traffic or excessive soil salinity[4], although symptoms differ slightly. In conifers, salt spray causes tip burn of one-year needles. In the spring the tips turn yellow and eventually brown, while the bases of affected needles stay green. There is a clear demarcation between the basal green and terminal brown tissue. The bases turn

brown in the fall and the needles drop early. Excessive soil salinity also causes tip burn, but the entire tree is affected rather than just parts exposed to salt spray. Another distinguishing symptom is that there is no new growth as buds fail to open.

Although there are differences in salt tolerance between tree species, no species is immune to damage. Even the most tolerant plants die if they are exposed to salt in sufficiently high concentrations. Since ponderosa pine is considered tolerant to salt spray and moderately susceptible to damage by excessive salt in soils, the salt induced mortality found along Highway 260 indicates that too much salt was deposited on the plants and in the soil. Although salts will be leached out of the soil by rainfall during the summer months, trees next to the highway will continue to be sprayed seasonally and to accumulate salt through roots, resulting in more damage.

If you have questions about this report, please email mfairweather@fs.fed.us or call me at (928) 556-2075.

/s/ Mary Lou Fairweather
MARY LOU FAIRWEATHER
Forest Pathologist, Forest Health, Arizona Zone

cc:
Gayle Richardson
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[1] Scharpf, R. and M. Srago. 1974. Conifer damage and death associated with the use of deicing salt in the Lake Tahoe basin of California and Nevada. USDA Forest Service California Region Forest Pest Control. Technical Report. 17 p.
[2] Strong, F.C. 1944. A study of calcium chloride injury to roadside trees. Michigan Quarterly Bulletin 27: 209-224.
[3] French, D.W. 1959. Boulevard trees are damaged by salt applied to streets. Minnesota Farm and Home Scientist 16: 9, 22, 23.
[4] Dobson, M.C. 1991. De-icing salt damage to trees and shrubs. Department of the Environment Arboriculture Contract. Forestry Commission Bulletin 101, 64p.